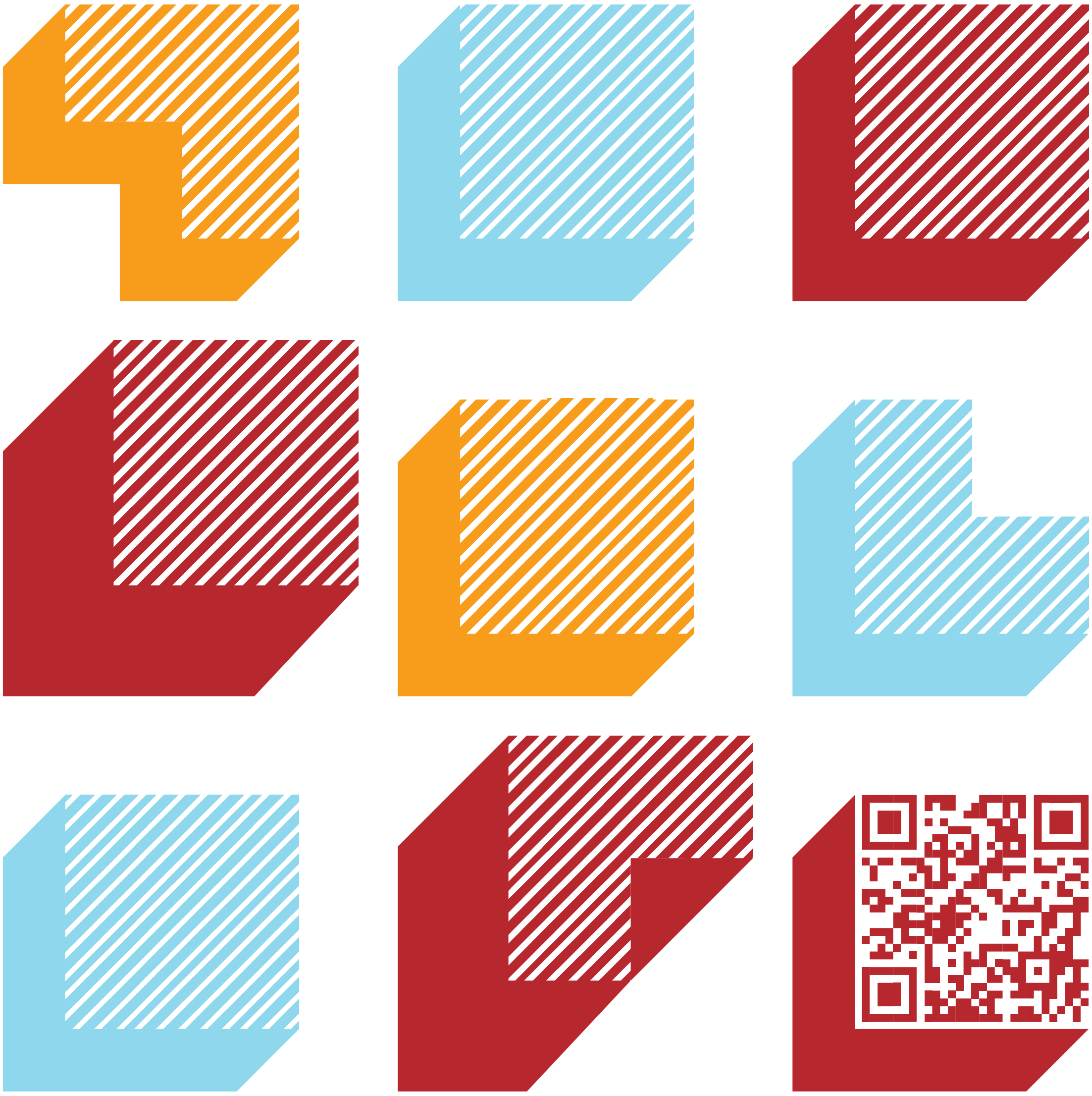

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LEARNING DESIGN *THROUGH* DESIGNERLY THINKING. HOLISTIC DIGITAL MODELING IN A GRADUATE PROGRAM IN ARCHITECTURE.

ABSTRACT: The paper presents the author's experiences in architectural design education as answers to questions that, for some years, have been hovering around Design as the *Third Culture* and its relationship with Science. More precisely, the paper proposes to address the following questions:

- **Can Design itself be used as a tool for scientific research? If so, what are its characteristics and features?**
- **Can research through Design be used as an educational method? If so, with what results?**

In addition, and as a complementary aspect, the paper also focuses on Modeling as a core language of Design that, in its recent digital nature, can bring accuracy to the production process, and "makes Science visible" so that an holistic approach in learning can be reinforced and usefully adopted.

I. Designerly Thinking as a research and learning methodology

"I do not believe that there is a single paradigm for research 'through design' but I am confident that we now have the means to conduct research that is appropriate to our profession and discipline, which makes a distinctive contribution to knowledge that complements that of other disciplines and, crucially, has the potential to inform professional [and educational] practice." (Rust, 2009: 6)

The relationship between science and design has a long and controversial story intimately connected with the beginning of design practice when the need for a scientific method, De Stijl, arose in the early Modern Movement and evolved within the cybernetic research of the 50's. The Conference on Design Methods, held in London in 1962 (Jonas and Thomley, 1963) is generally recognized as the climax of this debate and the point from where design starts to assume its own peculiar identity distinguished from science and the humanities. This question was revamped with the article *Research in Art and Design,* published in 1993 by Sir Christopher Frayling. The article renovated the question about the fundamental nature of design (Margolin, 1982), and the possibility for design to be a scientific research discipline: more specifically, if *Research through Design* can be considered a way of knowing but also a way of thinking to investigate and disseminate knowledge which are the main elements through which science is defined.

Addressing the above issues, this paper adopts the term *Designerly Thinking (Cross, 2001)* to designate the operational specific nature of design. It also identifies two questions as relevant topics to evaluate the scientific nature of design, consequently assessing *Designerly Thinking* as a useful approach in learning design. These two questions are:

- Does *Designerly Thinking* employ a rigorous and, above all, transmissible methodology?
- Does the product of *Designerly Thinking* modify systems of knowledge?

Historically, many scholars and practitioners have defined diverse and fragmented methodologies for design, and as a result, we must therefore accept that *Designerly Thinking* does not seem to employ a rigorous and transmissible methodology. However, because science and the humanities have moved closer together, science has opened itself to qualitative domains and concerns itself with ill-defined problem solving which are viable through multiform methodologies, even unorthodox ones, if they are reasonable and consistent. Based in this approach, we can accept *Designerly Thinking* as a scientific practice with its own multiform methodology but on the condition that the process is explicit, coherent and communicable.

Concerning the second question, whether or not the product of *Designerly Thinking* modifies existing systems of knowledge we can start from the seminal distinction between science and design (Simon, 1969) where the former is seen as a transformation process of *knowledge* and the latter a transformation process of *utility*. From this we conclude that design cannot modify systems of knowledge. But this is not definitive. In fact according to Brown and Chandrasekaran (1985) and Gero (1990), design, when it is not addressed as a *routine* product but *innovative* or *creative,* can produce different kind of changes in knowledge. In addition for others including Archer (1995), design artifacts can produce knowledge facilitating – sometimes – major changes in people's perceptions and values. The hypothesis that design can be assimilated to science is therefore valid under the condition that the changed state of knowledge does not remain *tacit,* but conscious and transmissible. In addition, this hypothesis is more relevant and effective in education where knowledge transformation can be considered its primary output even if it is not related to the scientific community or the whole of humanity but limited to a specific group of students in a class. Therefore, in this specific and limited field, *Designerly Thinking* can be considered a cognitive and scientific activity as well, if methodologies and products of research are explicit, consistent, and formalized.

II. Digital Modeling in Designerly Thinking as a medium of learning

From the above discussion it is clear that the questions "if *Designerly Thinking* can be based on a transmissible methodology and can produce a significant transformation on knowledge" are both related to the condition that all the activities, analysis, guessworks and outputs must be unambiguously expressed.

We believe that modeling, with pattern recognition and synthesis as the main and distinctive methods of Design, can be considered the answer. As we can see in the following examples, modeling represents the materialization of assumptions, methods and outputs: the medium through which students can objectify research, exchange experiences, and acquire knowledge.

Modeling has a long tradition based mainly on figuration: a personal sketching process (Laseau, 1989) developed by trials and errors, informed by *tacit* knowledge and controlled by *pondere et mensura* that, in the past, was typically analogical. In fact, with the exception of some drawings of Francesco di Giorgio Martini (see: School of Marco Varrone in Casinum) and the architectural firm of the San Gallo family, design modeling was mainly run through geometrical proportions. Famous examples are *Livre de*

Portraiture designed by the Picard architect-engineer Villard de Honnecourt in the decade from 1225 to 1235, the beautiful mock-ups realized by renaissance hatchers, or lately the elegant buildings of Palladio modeled using musical harmonic proportions. Even Vitruvio tells us of different measuring instruments but it is quite evident that the past reasoned and worked differently. It worked through the *analogical syllogism* of descriptive geometry and the ineffable knowledge of quality based on evidence.

Despite these historical antecedents, however, it was not until the Sixteenth century that The Number would start to accompany drawings in a more stable manner. While perspective in architecture was playing its baroque exaggerations, the *Scientia Mathematica* revolutioned design and architecture supporting Cartesian Space where objects and functions were describable with the elegance of numbers and mathematical formulas. From this moment onwards, Aristotelian geometry was threatened by a new approach which was no longer syllogism but numerical modeling. The forerunners of this new approach were the abstract ballistic calculations and crossfire lines that shaped urban fortifications.

The *Matema* paradigm-shift marked the passage, as stated by Fulvio Carmagnola, *"from a qualitative quality to a quantitative quality"* where also analogical representations and high fidelity models are derived from the quantitative logic of digital computation (Maldonado, 1992). As a result, nowadays, forms and behaviors of materials can be shaped and crafted to achieve particular design goals fitting exactly the visualization that designers are able to produce with their computer software. The standardization of elements is no longer a technique to build in an industrial way. Digital information has become the standard and designers, industry and craftsmen are using this standard to model, to share knowledge and, more than that, to formalize ideas: to give evidence of the design research process and *Designerly Thinking* as well.

Rooted in this theoretical basis, three teaching examples from a Graduate Program of the School of Architecture in Florence are presented. Common elements of these examples are the use of exploratory research and digital modeling able to produce a great number of tests and corrections especially if it is parametric or evolutionary and therefore more effective compared to the physical modeling. Furthermore, reflecting the same principle that distinguishes Research *through* Design from Research *for* Design, the examples share the criterion that the artifacts made by students are not evaluated for the quality of the product *in itself* but for the degree of knowledge enabled through the artifacts.

III. Form manufacturing

The first example comes from the «Architecture and Structure Design Lab», specifically the *Form Manufacturing* Class, where learning proceeds from a free intuitive activity towards a more formalized approach ending in the digital fabrication of prototypes. The course begins with Origami/Kirigami manipulation inspired by the paper exercises of Josef Albers and his quote: "*All art starts with a material, and therefore we have first to investigate what our material can do"*.

This introductory exercise (*Forming through Matter),* is based on free exploration and intuitive perception about *matter*'s behaviors in order to gain awareness of the relationships between the *materia prima* (in Latin definition or *materia rudis, corpora materia* in Lucrezio's acception: contents without form but factive) and the *form* through which materiality (*materia operata*) emerges.

Form Modeling is the second step, where students are first required to induce, from their experiments, forming regulatory diagrams such as *mountain & valley-fold*, or consistent methodologies such as tessellation to test, control and refine ideas. Eventually, this formalistic part ends with digitalization where experiments are run in a virtual way using 2D patterning, 3D and parametric modeling.

After the exploratory phase, the class enters the conclusive stage with the final assignment (*Form*

Fabrication) where students are required to produce a mock-up in rapid prototyping for a structural or envelope system. The mock-up and its evaluation are not related to its capacity to represent qualitative aspects and the morphology of the real building system (the form *in itself*). Instead, the goal is to model, to let emerge, the materiality of the constructability: relationships, procedures, and criteria that must be observed in the designing activity finalized for fabrication. To reinforce this goal some constraints were deliberately imposed: the exclusive use of flat elements obtained from laser cutting and the assembly process could not using glue, nails or screws.

IV. Holistic Learning through HI-FI modeling

Modeling, as operational research and learning tool, is also the main concentration of the second teaching example. In this class, from the «Environmental Design Lab», modeling entirely refers to the digital prototyping. Explorations are carried out inside the virtual dimension simulating and testing performative *matter* of materiality. In this case, the model is used, not as a mere presentation of phenomena, but as a cognitive artifact that allows the student to interact and become familiar with the theoretical foundations that the prototype incorporates: expression of concrete thought and formalization of the traditional sketching in a way it can be now used as a shareable instrument of scientific research (Papert, 1996). The goal of the class is the architectural and environmental retrofit of an existent building to approach in a performative and computational manner.

As in the Form Manufacturing class, in the first phase (*Forming through performances*) students are asked to carry out a theoretical exploration through which they could acquire foundational knowledge about *matter,* in this case concerning the physical determinant of building elements *versus* environmental behaviors, and *form*, concerning their state configurations. As a *basic* activity, from this preliminary exploration, knowledge about theoretical and instrumental fundamentals is also produced.

The second assignment titled *Options Building*, concerns the decision-making process to be formalized, in a *scientific* manner, through the preliminary definition of assumptions, criteria, outputs and the adopted system for alternatives comparison as well. In some advanced cases and in very limited aspects of the projects, evolutionary computation is also solicited. The objective is not the identification, *tout court,* of a preferred solution, but the acquisition of the Design Optioneering methodology: the design optimization process recently redefined and practiced through a parametrical approach (Shea and Gourtovaia, 2005; Holzer, 2007). In this phase attention is devoted to communication and requires the translation of the digital entities of modeling in analogic shapes. For this goal students are asked to convert numerical reports in more understandable and shareable info-graphics and to give evidence of immaterial aspects of design such as temperature, wind, light, ... through 3D visualizations and HI-FI models that, because the digital information (the untouchable material) stored and processed in it, is able to give us a tangible and qualitative experience of the quantitative analyzed phenomena.

Materializing relationships and emerging effects between building and environment is also the final assignment titled *Materializing Behaviors* where students are asked to finalize their experience showing the changing state of this intra-active system under different conditions of forms, building elements, weather and *time* as the complementary entity of *form* and *matter*. Virtual representation through video animation is the required medium to show this relationship, but students are also encouraged to produce an interactive physical prototype using Arduino microcontrollers. For the realization of adaptive mock-ups students are supported by Mailab (www.mailab.biz) a university spin-off research laboratory on Multimedia Architecture and Interaction, giving them the opportunity to expand their learning experience in a professional research context.

V. Staging Inhabitants' Behaviors

The last example is the workshop "*La casa di …"* focused on designing a private house where the main goal is to invalidate the current use of standardized users' requirements and, more importantly, to disrupt the traditional approach in design-lab teaching where students work with a problem-solving attitude. For the final presentation students are required to realize an architectural video-mapping installation where the architecture (a Communal Condo resulting from the assemblage of all the individual houses) is in the background: a simple three-dimensional support to stage the daily life of each user or *"different biographies of many weak identities.* (A. Branzi, 2009: 39)

According with this goal, the assignment starts with the brief definition (*Client profile*). A problem setting task that students are asked to cover using uncommon approaches for architects such as creative writing and daily activities scoring or other unorthodox instruments such as virtual shadowing (e.g. Vito Acconci's *Following Piece).* The goal is to provide a design program emerging from people as human beings: a complex anthropological subject, more than ergonomic and psychophysical entities where provocative and ironic approaches (e.g. Munari's Method, Architettura Radicale, Critical Design) were also solicited to restructure the problem.

In the second step (*Design Development*) students were asked: first, to work individually designing a private house fitting some assigned morphological constraints and users' requirements as set in the previous phase; second, to work as a group in order to realize a unique model reassembling all the individual houses in a Communal Condo to be manufactured in rapid prototyping.

The third step (*the Spectacular Communal Condo*) was devoted to reveal the daily behaviors of the houses and their inhabitants through videoclips. With the assistance of Mailab, these videoclips were assembled, edited and mapped on the physical model in order to obtain a video-installation staging the life of the Condo and to materialize a metaphor of the condition of contemporary design where objects are vanishing in a new scenario *that "pushes material artifacts to the background in favor of the actors within the system, […] will invite designers to look for the 'dark side' of the object […] that correspond, not only to the needs, but also to the aspirations, hopes, and life projects of their users!"* (Findeli, 2001: 14-15)

VI. Conclusions

The discussed examples show how learning can have effective benefit from practices informed by scientific research or, in other words, by formalized and consistent methodologies supported by modeling.

According to Epron et al (1977) the better impact of modeling compared to other approaches based on regulatory methods or stylistic observation is also demonstrated in learning. In a broader context, some other corollaries concerning the adoption of the *Designerly Thinking* and Digital Modeling adopted in *explorative* more than *experimental* attitude, in Bardram's et al. (2004) interpretation, can be also highlighted in the following:

- *form*, *matter* and *time* are mutually interrelated in the manufacturing process and they can be effectively modeled through information materiality;
- problem setting and the *construction* of ad-hocratic tools are strategic and determinant in design practice facing new problems;
- HI-FI analogical representation can be a powerful tool to acquire awareness and to support the decision-making process as well as learning;
- qualitative and analogical comparisons allowed by digital computation, more than analytical measurements, can produce evidence and effective evaluation of alternatives in the early stage of design;

- provocative and disruptive approaches can stimulate students to interplay, to identify new directions and to expand their knowledge;
- new knowledge emerges from the interplay between the environment, artifacts and actors and, as a consequence, each learning project has different goals, methods and outputs.

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